Science as a Way of Knowing

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SCIENCE AS A WAY OF KNOWING

Howard Stein

A task force in the Science & Mathematics Division has been working on a new pair of courses to add to the General Education menu in the sciences, SCIENCE 101 and 102 Science As a Way of Knowing. What follows is an overview of the thinking of the task force.

The Science categories of General Education require students to complete courses in the Life and Physical Sciences and to include a laboratory component. The collective intent of those requirements forces some breadth and some involvement in the practice of science. The SCI 101 and 102 package fulfills each of those requirements but in a different fashion than originally envisioned by the framers of the requirements.

The premise behind the courses is that all educated people in our age need to be scientifically literate. Knowledge of one or two of the major sciences is not sufficient. Science literacy includes familiarity with the natural world, understanding of key concepts and principles of the sciences, and awareness of the interdependence of science and technology. A scientifically literate person has the capacity for a scientific way of thinking, can describe the natural world mathematically, recognizes the limits of science, and applies scientific knowledge and habits of mind for individual and social purposes. SCI 101 and 102 are planned to approach these goals of scientific literacy in an interdisciplinary way, touching upon the major concepts of all of the natural sciences.

These courses are designed to be completed as a unit. SCI 101 and 102 are to be taken in successive semesters. The laboratory is to be offered in alternate weeks throughout the year.

The following outline, derived largely from Project 2061: Science For All Americans (American Association for the Advancement of Science, 1989) summarizes our intentions:

I. The nature of science

A. Scientific world view: Scientists share certain beliefs and attitudes about what they do.

1. The world is understandable.
   Things and events in the universe occur in consistent patterns which are comprehensible through careful, systematic study.

2. Scientific knowledge is subject to change.
   Change in scientific knowledge is inevitable because new knowledge challenges prevailing theories.
3. Scientific knowledge is durable.
   The modification of knowledge, rather than outright rejection, is the norm in science. Powerful constructs tend to grow more precise and to become more widely accepted.

4. Science cannot provide answers to all questions.
   Certain beliefs cannot be explained by scientific methods.

B. Scientific inquiry: Fundamentally the sciences are alike in their reliance on evidence, the use of hypotheses and theories, and the kinds of logic used.

   The validity of scientific claims is settled by referring to observations of phenomena.

2. Science is a blend of logic and imagination.
   Although all sorts of imagination and thought may be used in coming up with hypotheses and theories, sooner or later scientific arguments must conform to the principles of logical reasoning.

   The credibility of scientific theories often comes from their ability to show relationships (often mathematical) among phenomena which were previously thought to be unrelated.

4. Scientists try to identify and avoid bias.
   Bias attributable to the investigator, the sample, the method, or the instrument may not be completely avoidable, but scientists want to know the possible sources of bias and how bias is likely to influence the evidence.

5. Science is not authoritarian.
   Scientists accept the concept that even the most eminent scientists can be wrong, that no one is empowered to decide for other scientists what is true.

C. The scientific enterprise: Scientific activity is one of the main features of the contemporary world and distinguishes our times from earlier centuries.

1. Science is a complex social activity.
   Science is pursued in many different settings and in many different countries by many different kinds of people. The dissemination of new scientific discoveries involves communication, questioning, and criticism within the international scientific community.

2. Science is organized into content disciplines and is conducted in various institutions.
   The various disciplines overlap and interact with each other, and new scientific disciplines are continually being formed. Universities, industry, and government are all part of the scientific endeavor.

3. There are generally accepted ethical principles in the conduct of science.
   Strongly held traditions of accurate record keeping, openness, and
replication, buttressed by critical reviews of one's work by peers, serves to keep the vast majority of scientists within the bounds of ethical professional behavior.

4. Scientists participate in public affairs both as specialists and as citizens. Scientists can bring information, insights, and analytical skills to bear on matters of public concern.

II. The nature of technology: Technology extends our ability to change the world.

A. Science and technology

1. Technology draws on science and contributes to it.
   In addition to accumulated practical knowledge, understanding how things behave contributes to development of technology.
2. Engineering combines scientific inquiry and practical values.
   The component of technology most closely allied to scientific inquiry and to mathematical modeling is engineering.

B. Principles of technology

1. The essence of engineering is design under constraint.
   Such limits as physical laws, economics, and risk must be taken into account in seeking optimum design.
2. All technologies involve control.
   All systems require control to keep them operating properly.
3. Technologies always have side effects.
   Unintended side effects accompany the production and application of designs.
4. All technology systems can fail.
   The more complex a system, the more components can contribute to failure.

C. Technology and society

1. Technological systems and social systems interact strongly.
   Social and economic forces influence which technologies will be undertaken, paid attention to, invested in, and used.
2. The social system imposes some restrictions on openness in technology.
   Large investments of time and money in developing technologies can be jeopardized by sharing knowledge with potential competitors.
3. Decisions about the use of technology are complex.
   Though most technological innovations respond to free market forces, some technologies are subject to public debate and formal regulation.

The scientific literacy goal, emphasis on knitting together the sciences, and many
connections with social science and humanities disciplines position this package of courses as a good exemplar of the General Education ideals. By downplaying science as a mass of facts and highlighting the philosophy of science, Science As a Way of Knowing provides students with a substantial means to compare science with other divisional categories of General Education.